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AN ILLINOIS RECORD COPPER ERRATIC

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In various places in Illinois, chiefly in association with Illinoian and Wisconsin drifts, numerous pieces of drift copper have from time to time been found.

The table below gives a list of all these specimens known to the writer, together with their weight, dimensions, name of the finder, locality where discovered and where preserved.

Eleven counties mostly north of the center of the State are represented by the nineteen occurrences recorded. The most southerly point is Effingham, about one hundred miles from the southern end of the State.

The nuggets were all found in Wisconsin or Illinoian drift, none in older drift. Mr. Leverett has pointed out that copper erratics from the Lake Superior region are found as far east as northwestern Pennsylvania and there are contained in Kansan drift, since these ice sheets came from Labrador and moved south-eastward, while Illinoian and Wisconsin sheets came from Labrador and moved in a southwestward direction. In fact, all such erratics found from central Indiana through Ohio to western New York and Pennsylvania may be referred to the Kansan, while those occurring in western Indiana, Illinois and eastern Iowa were transported during the Illinoian or later ice stages.

All of the copper masses, small or large, are more or less rounded, lack protruding crystal groups, and often show glacial markings and malachite coatings. Six specimens in the Illinois State Museum are shown on plate A.

The lumps recorded in the table range in weight from a fraction of an ounce to 1606 pounds. As far as is known, the latter, which is preserved in the State Museum, is the largest mass ever found in Illinois. It is fifty-one inches long, thirty-four and one-half inches high and six inches thick.

COPPER ERRATICS IN ILLINOIS

No.	WEIGHT AVOIR.	SIZE IN INCHES LENGTH BREADTH THICKNESS	WHERE FOUND	BY WHOM	WHERE PRESERVED	CAT. No.	REMARKS
1	3 oz.	$1\frac{3}{4} \times 1\frac{1}{2} \times \frac{1}{2}$	Shirley, McLean Co.	Gates	State Museum	3382	2 Pieces.
2	5 oz.	$2 \times 2 \times \frac{1}{4}$	Spaulding, Sangamon Co.	Joseph Spain	"	5389	2 Pieces. Thick malachite incrustation.
3	3 lbs.	$5\frac{1}{2} \times 5 \times 1\frac{1}{8}$	Murrayville, Morgan Co.	Wm. H King.	"	5279	
4	11 lbs. 12 oz	$8\frac{1}{4} \times 4\frac{1}{2} \times 3\frac{3}{8}$	.....	.....	"	3383	
5	17 lbs. 13 oz.	$9\frac{1}{4} \times 5\frac{1}{2} \times 2\frac{1}{2}$	Macon Co.	Asa Eastman	"	693	
6	18 lbs. 10 oz.	$10\frac{1}{2} \times 8\frac{1}{4} \times 2\frac{1}{2}$	Peoria Co.	"	"	695	Hole at one end to hang on wire to close garden gate.
7	1606 lbs.	$51 \times 34\frac{1}{2} \times 6$	8 mi. w. of Canton, Fulton Co.	L. J. Paul	"	5590	Largest copper mass found in Illinois.
8	2/5 oz.	$1\frac{3}{8} \times \frac{1}{2} \times \frac{3}{8}$	.....	J. E. Lamar	J. E. Lamar, Ill. State Geol. Surv.	.....	Reported by A. Oldfather
9	1.4 oz.	$1\frac{1}{2} \times \frac{5}{8} \times \frac{1}{4}$	.....	"	"	.....
10	2 oz.	$2\frac{1}{4} \times 1\frac{3}{4} \times \frac{1}{8}$	3 mi. S. W. of Dixon, Lee Co.	"	"	.....
			S. W. of Am- boy, Lee Co.	"	"	.....
11	3.7 oz.	$2\frac{3}{4} \times 1\frac{1}{2} \times \frac{1}{4}$		Favour	G. F. Moulton	.....

12	2 lbs.	3×2×—	.....	.....	.....	.....	.....
13	2 lbs.	3×3×—	.....	.....	Univ. of Ill. Geol. Dept.	.....	W. S. Bayley.
14	2.5 lbs.	5×3×—	.....	.....	" "	.....
15	3.5 lbs.	6×3×—	.....	.....	" "	.....
16	2.25 lbs.	.....	.....	.....	" "	.....
			Near Ottawa, Lasalle Co. Effingham, " Co. S. E. of Rock- ford, Winne- bago Co. Richardson Sand Co., Elgin, Kane Co.	Higby Canyon, Sand Co. J. A. Udden	Univ. of Ill. Museum, N. H. Augustana College. Univ. of Chicago Rosenwald Hall	A1806	Frank C. Baker.
17	1 oz.	1 $\frac{1}{4}$ ×1 $\frac{1}{4}$ × $\frac{1}{4}$	.....	.....	.....	.....	F. M. Fryxell.
18	3.75 lbs.	6×2 $\frac{3}{4}$ ×1 $\frac{1}{4}$	.....	.....	.....	.....	J. H. Bretz. Figured on page 214, Bull. 43, <i>Ill. State Geol. Survey</i> .
19	18 lbs.	11 $\frac{1}{4}$ ×6×1 $\frac{3}{4}$	.....	G. A. Gunderson	Supt. Sand Co. Elgin.	.....	G. E. Ekblaw.

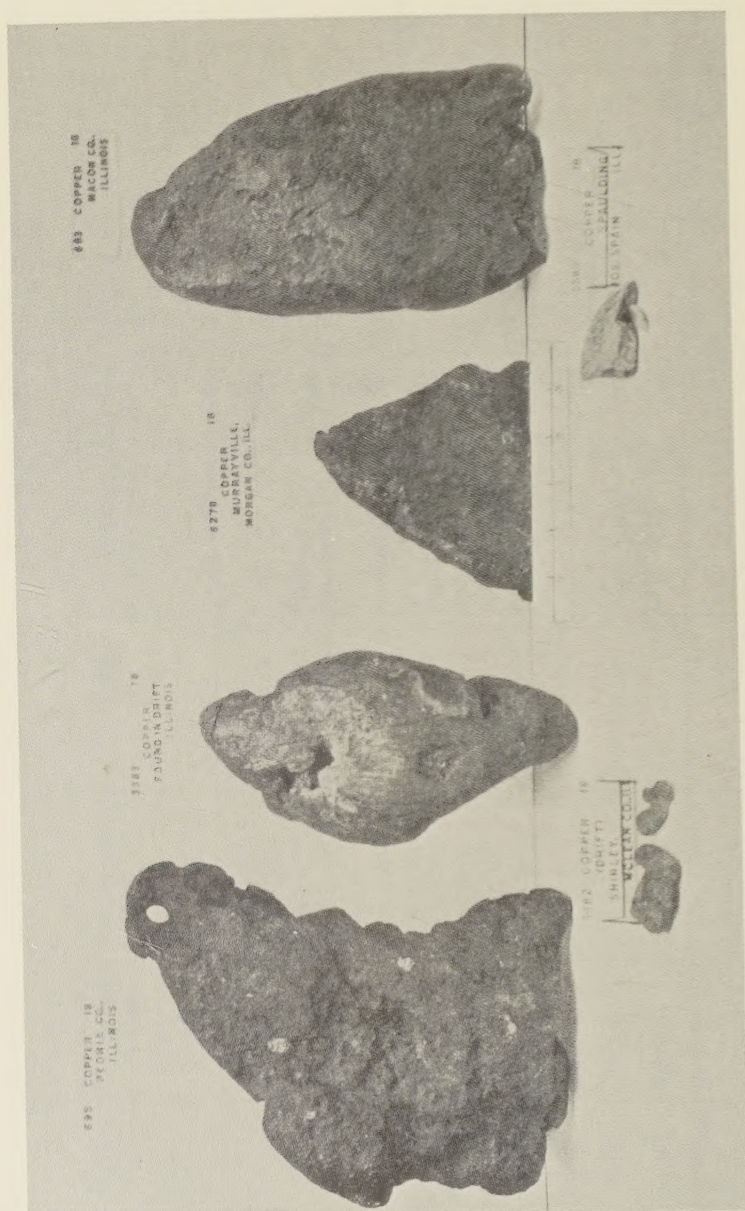


PLATE A. Six specimens of native Copper in Illinois State Museum.

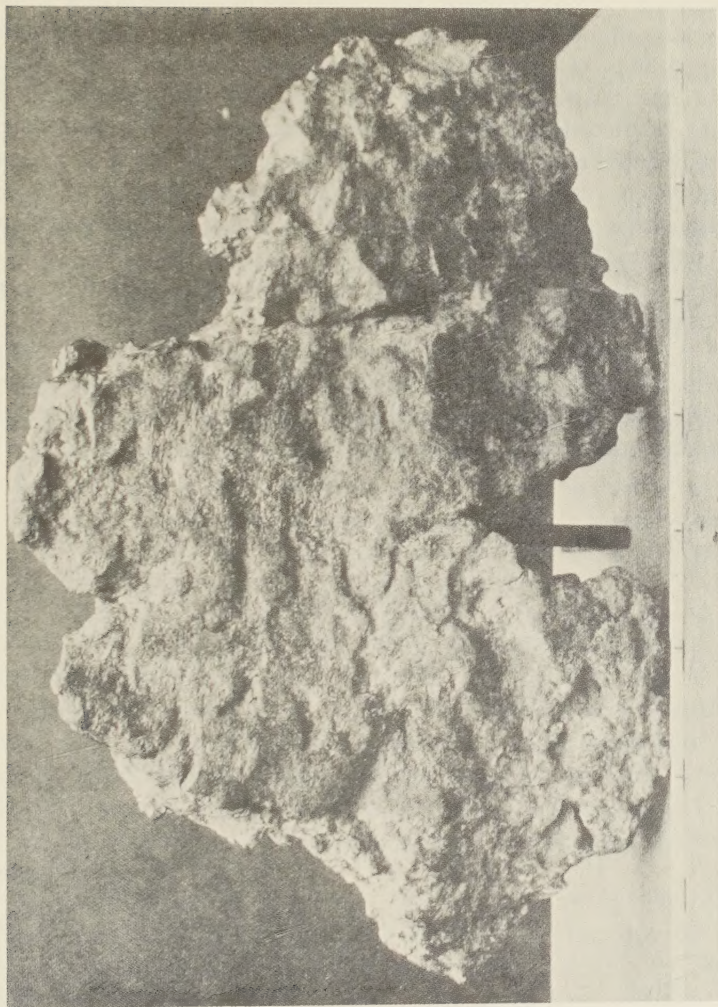


PLATE B. Largest Copper mass found in Illinois. Now in State Museum.

It was found in the fall of 1927 by L. J. Paul who was hunting on his farm eight miles southwest of Canton, Fulton County, Illinois. A mink had hidden in a pile of brush at the bottom of a small gully. To drive it out, the farmer set fire to the brush. Some time later as he was pushing the ashes aside, the heel of his boot scraped on a metallic substance. Noticing that it was yellow and shiny, he tried to find the outline of the mass. He thought that it might be buried gold so he worked alone. As it was located in the bottom of a gully it was in a difficult place to work and great effort was necessary to dig it out. Finally it was placed on skids, fastened to a tractor and drawn onto level ground. Soon neighboring souvenir hunters began to cut off protruding portions with chisels and saws, so the farmer buried it again. Later it was removed and sent to the State Museum.

It is an irregular, rather oblong mass with a few projections. (Plate B.) The malacite coating is chiefly in protected places. On the flat sides glacial striae are in evidence. Quartz crystals appear in places but no silver is discernable.

DISPERSION OF MINERALS

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The new methods of studying powdered minerals lead naturally, not only to a knowledge of their indices of refraction in ordinary light, but also and simultaneously to a knowledge of the variation in their indices with variation in the wave-length (or color) of light; that is, the new methods lead to a knowledge of the dispersion of minerals. Of course, the dispersion of a mineral is as definite a physical property as its refringence or birefringence and, therefore, may be used to identify it. At present, data regarding the dispersion of minerals are remarkably scanty and in some cases not very accurate. All available data on dispersion (of reasonable accuracy) are assembled in the following table. In order to make these data useful for determinative purposes, the minerals are classified first in groups of increasing dispersion, and then arranged in each group in the order of increasing refringence.

The dispersion given is always the difference between the index in light of 4861 Å wave-length (=the Fraunhofer line F or the β line of hydrogen) and the index in light of 6563 Å wave-length (=the Fraunhofer line C or the α line of hydrogen). In the tables this dispersion is meant by the expression F-C.

In anisotropic crystals the dispersion of the substance is, in general, not the same for light vibrating in directions which are crystallographically unlike. Therefore the dispersion for N_g is not the same as for N_p , and the dispersion for N_m is not equal to that for N_g nor to that for N_p . However, these differences are usually small, and the only dispersion given in the table is that for N of isotropic substances, N_o of uniaxial substances and N_m of biaxial substances (with rare exceptions, in cases where data are not available for N_m).

In the literature the dispersion is rarely given directly and the indices measured for different wave-lengths do not always include the wave-lengths of the F and C lines, which are the standards used in computing the dispersion. Therefore, it is necessary to obtain this dispersion by graphic (or mathematical) solution in many cases; when this involves considerable extrapolation the value of the dispersion is followed by the \pm sign. In order to permit checking of this extrapolation and also to permit the preparation of dispersion curves for all minerals, the original data

are given for yellow (the sodium D line unless otherwise noted), blue (or green—the exact wave-length given whenever known) and red (the wave-length given, if known). If a chemical analysis of the mineral sample whose dispersion was measured is available, the name of the mineral is followed by an asterisk. Finally, in order to permit verification of the data, the name of the observer and the place of publication are given in all cases. If a later publication of the data is probably more accessible than the first, that is commonly given preference.

The dispersion of minerals increases, in general, with their refringence; nevertheless, minerals of the same refringence do not necessarily have the same dispersion. An interesting and possibly important illustration of this fact is furnished by the data regarding sillimanite and mullite. These two minerals are so much alike that Eitel¹ and Rinne² consider that they are not essentially different. They are both orthorhombic and have crystal forms which are very similar. The common prism faces are nearly at right angles to each other and both minerals have perfect cleavage parallel to the brachypinacoid. In fact, Wyckoff³ was at first unable to distinguish between them by means of X-ray patterns, though he later found⁴ “very slight but probably real differences.” In optical properties, also, they are almost identical. According to Bowen, Greig and Zies,⁵ they both have the optic plane parallel with the perfect cleavage and in both the slow ray vibrates parallel with the vertical axis, giving positive elongation. They have the same optic sign, nearly the same refringence, nearly the same birefringence and nearly the same optic angle; in fact, when mullite contains four to five percent of ($\text{TiO}_2 + \text{Fe}_2\text{O}_3$), it is indistinguishable from sillimanite even by means of accurate measurements of these optic properties. According to Bowen, Grieg and Zies, such mullite can be distinguished from sillimanite by chemical analysis or by the fact that it is colored and pleochroic while sillimanite is colorless. Since differences between mullite and sillimanite are so difficult to find, it seems important to note that the dispersion of mullite (.026) is more than double that of

¹ *Zeit. Kryst.*, **LXIV**, 1927, p. 535.

² *Zeit. Kryst.*, **LXI**, 1925, p. 113.

³ *Jour. Am. Cer. Soc.*, **VII**, 1924, p. 253.

⁴ *Am. Jour. Sci.*, **CCXI**, 1926, p. 459.

⁵ *Jour. Wash. Acad. Sci.*, **XIV**, 1924, p. 183.

sillimanite (.01 to .012) according to data now available. This difference, like the color, is doubtless due in part to the small tenor of ($\text{TiO}_2 + \text{Fe}_2\text{O}_3$) in the mullite. It seems improbable to the writer that it is due wholly or even chiefly to the titanitic acid and ferric iron, and, if mullite containing none of these substances has a dispersion notably higher than that of sillimanite, it would be difficult to explain that condition on the basis of submicroscopic inclusions of corundum in sillimanite, since the dispersion of corundum is no greater than that of sillimanite. Of course, it is also difficult to understand why admixed corundum (with $N=1.76$) should lower the indices of sillimanite from about 1.67 to about 1.65.

It is clear that minerals differ in their dispersion, and in some cases this difference will be very useful in distinguishing between them. The scanty data now available are summarized in the following table. Such data will doubtless become much more abundant as the new dispersion methods of measuring indices of refraction come into wide usage.

DISPERSION OF MINERALS

N, N ₀ or N _m					Mineral	Authority	Reference
F-C	D	Blue	Red				
Section 1. N _F -N _C = .000 to .0075							
.0062	1.309	1.3129 (492)	1.3069 Li	Ice	A. Ehringhaus:-	<i>N. Jahrb. Min. Bl. Bd. XLI</i> , 1917, p. 369.	
.0039	1.3258	1.3285 F	1.3246 C	Villiaumite	K. Spangenberg:-	<i>Zeit. Kryst.</i> , LVII , 1923, p. 494.	
.004 ±	1.3395	1.3408 Tl	1.3382 Li	Cryolithionite*	N. V. Ussing:-	Dana: <i>System Min.</i> , App. II, 1909, p. 33.	
.004	1.4339	1.4369 F	1.4326 Li	Fluorite	S. Kozu:-	<i>Mineral. Mag.</i> , XVII , 1916, p. 256.	
.0049	1.4425	1.4462 F	1.4413 C	Yttrofluorite*	F. Zambonini:-	<i>Zeit. Kryst.</i> , LVI , 1921, p. 219.	
.0071	1.4629	1.4678 F	1.4607 C	Picromerite (art.)	A. E. H. Tutton	<i>Trans. Chem. Soc. London</i> , LXXXVII , 1905, p. 1173.	
.006 ±	1.502	1.506 bl	1.500 red	Prosopite	A. Des Cloizeaux:-	Dana: <i>System Min.</i> 1892, p. 178.	
.006	1.5084	1.5131 (475)	1.5073 (633)	Nocerite*	F. Zambonini:-	<i>Zeit. Kryst.</i> , LVI , 1921, p. 219.	
.0065	1.5329	1.5343 Tl	1.5281 Li	Langbeinite	O. Luedecke:-	<i>Zeit. Kryst.</i> , XXIX , 1897, p. 255.	
.005 ±	1.5457	1.5480 Tl	1.5448 red	Eudidymite*	W. C. Broegger:-	<i>Zeit. Kryst.</i> , XVI , 1890, p. 586.	

	1.5812	1.5849 Tl	1.5802 Li	Scapolite	A. Laitakari:- G. Flink :-	<i>Bull. Com. Geol. Finland</i> , LIV , 1921, p. 76. Dana: <i>System Min.</i> , 1892 , p. 388.
.007 ±	1.5812	1.5849 Tl	1.5802 Li	Scapolite	A. Laitakari:-	
.006 ±	1.618	1.620 Tl	1.616 Li	Tremolite	G. Flink :-	
Section 2. $N_F - N_C = .0075$ to .0085						
.0079	1.4554	1.4611 F	1.4532 C	Epsomite	Borel:-Groth:-	<i>Chem. Kryst.</i> , II , 1908, p. 430.
.0077	1.4560	1.4614 F	1.4537 C	Potassalumite	A. Mulheims:-	<i>Zeit. Kryst.</i> , XIV , 1888, p. 223.
.0081	1.4694	1.4750 F	1.4669 C	Borax (art.)	Dufet:-Groth:-	<i>Chem. Kryst.</i> , II , 1900, p. 132.
.0081	1.4730	1.4786 F	1.4705 C	Boussingaultite (art.)	A. E. H. Tutton:-	<i>Trans. Chem. Soc. London</i> , LXXXVII , 1905, p. 1123.
.0084	1.4801	1.4860 F	1.4776 C	Goslarite (art.)	Topsoë and Christen- son:-Groth:-	<i>Ann. Phys.</i> , I , 1874, p. 63; <i>Chem. Kryst.</i> , II , p. 437;
.008 ±	1.4888	1.4949 F	?	Morenosite (art.)	Topsoë and Chr:- Groth:-	<i>Ann. Phys.</i> , I , 1874, p. 63; <i>Chem. Kryst.</i> , II , p. 437.
.008	1.5080	1.5107 Tl	1.5050 Li	Leucite	F. Zambonini:-	<i>Zeit. Kryst.</i> , LV , 1915, p. 299.
.008	1.5095	1.5115 Tl	1.5050 Li	Pirssonite*	J. H. Pratt:-	<i>Am. Jour. Sci.</i> , II , 1896, p. 126.
.008 ±	1.5124	1.5148 Tl	1.5093 Li	Flagstaffite (art.)	Arzruni:-Groth:-	<i>Chem. Kryst.</i> , III , 1910, p. 658.

* Analysis given.

DISPERSION OF MINERALS

F-C	N, N ₀ or N _m			MINERAL	AUTHORITY	REFERENCE
	D	Blue	Red			
.008	1.5156 (570)	1.5207 (475)	1.5128 (633)	Cancrinite*	F. Zambonini:-	<i>Zeit. Kryst.</i> , LV, 1915, p. 305.
.008	1.5225	1.5282 F	1.5195 Li	Adularia	S. Kozi:-	<i>Mineral. Mag.</i> , XVII, 1916, p. 253.
.0079	1.5229	1.5283 F	1.5204 C	Gypsum	Lang:-	<i>Sitz. Akad. Wiss. Wien</i> , LXXVI, 1877, p. 793.
.0083	1.5251	1.5312 F	1.5225 Li	Sanidine	S. Kozi:-	<i>Mineral. Mag.</i> , XVII, 1916, p. 238.
.008	1.533	1.539 F	1.531 C	Albite	S. Tsuboi:-	<i>Mineral. Mag.</i> , XX, 1923, p. 108.
.0084	1.5376	1.5474 (453)	1.5343 (667)	Nephelinite*	F. Zambonini:-	<i>Zeit. Kryst.</i> , LV, 1915, p. 302.
.0084	1.5372	1.5431 F	1.5347 C	Ordierite*	L. Oppenheimer:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 312.
.0083	1.543	1.548 F	1.540 C	Oligoclase	S. Tsuboi:-	<i>Mineral. Mag.</i> , XX, 1923, p. 108.
.008 ±	1.5441	1.5466 green	1.5417 red	Epididymite	G. Flink:-	<i>Med. Grön.</i> XXIV, 1901, p. 70; <i>Zeit. Kryst.</i> , XXXIV, 1901, p. 653.
.0078	1.5442	1.5497 F	1.5419 C	Quartz	A. Ehringhaus:-	<i>N. Jahrb. Min., Bt. Bd.</i> , XLIII, 1920, p. 602.

DISPERSION OF MINERALS

N, N ₀ or N _m				MINERAL	AUTHORITY	REFERENCE
F-C	D	Blue	Red			
.009 ±	1.4790	1.4817 Tl	1.4763 Li	Natrolite*	W. A. Broegger:-	<i>Zeit. Kryst.</i> , III , p. 480; XVI , p. 615.
.009 ±	1.4827	1.4855 Tl	1.4796 Li	Sodalite*	K. Feussner:-	<i>Zeit. Kryst.</i> , V , p. 581.
.0091	1.5246	1.5309 F	1.5218 C	Cancrinite	M. Albis:-	<i>Rend. Accad. Lincei</i> , XXX , 1920, p. 472.
.009 ±	1.5247	1.5273 Tl	1.5215 Li	Pollucite*	S. L. Penfield:-	<i>Am. Jour. Sci.</i> , XLI , 1891, p. 213.
.009 ±	1.5281	?	1.5251	Anorthoclase*	F. Fouqué:-	<i>Bull. Soc. Fr. Min.</i> , XVII , 1894, p. 283.
.0089	1.5344	1.5408 F	1.5319 C	Apophyllite	A. Ehringhaus:-	<i>N. Jahrb. Min., Bl. Bd.</i> , XLI , 1917, p. 374; and XLIII , 1920, p. 602.
.0087	1.5376	1.5474 (453)	1.5343 (667)	Nephelite*	F. Zambonini:-	<i>Zeit. Kryst.</i> , LV , 1915, p. 302.
.009 ±	1.5385	1.5409 Tl	1.5348 Li	Gismondite	F. Rinne:-	<i>Sitz. Akad. Wiss. Berlin</i> , 1890, p. 1023; <i>Zt. Kr.</i> , XX , 1892, p. 302.
.009	1.546	1.5523 F	1.5433 C	Cordierite*	L. Oppenheimer:-	<i>Zeit. Kryst.</i> , LVIII , 1922, p. 312.
.0086	1.552 ±	1.558 F	1.549 C	Andesine	S. Tsuboi:-	<i>Mineral. Mag.</i> , XX , 1923, p. 108.

.0087	1.5579	1.5604 Tl	1.5550 Li	Beryllonite*	E. S. Dana:-	<i>Am. Jour. Sci.</i> , XXXVII , 1889, p. 23.
.009	1.563 ±	1.569	1.560	Labradorite	S. Tsuboi:-	<i>Mineral. Mag.</i> , XX , 1923, p. 108.
.0093	1.573	1.579 F	1.570 C	Bytownite	S. Tsuboi:-	<i>Mineral. Mag.</i> , XX , 1923, p. 108.
.009	1.574 ±	1.580 (480)	1.571 Li	Beryl	Offret:- Hintze:-	<i>Hdb., Min.</i> , II , 1897, p. 1273.
.0095	1.583	1.5895 F	1.580 C	Anorthite	S. Tsuboi:-	<i>Mineral. Mag.</i> , XX , 1923, p. 108.
.009	1.5873	1.5901 Tl	1.5838 Li	Scapolite*	R. Brauns:-	<i>Zeit. Kryst.</i> , LVII , 1922, p. 214.
.009	1.5893 (578)	1.5944 (492)	1.5851 (691)	Hambergite	A. Ehringhaus:-	<i>N. Jahrb. Min., B. Bd.</i> , XLI , 1917, p. 381.
.009	1.5920	1.5981 F	1.5892 C	Colemanite	A. Mulheims:-	<i>Zeit. Kryst.</i> , XIV , 1888, p. 230.
.0094	1.6022	1.6085 F	1.5991 C	Zunyte	M. Albis:-	<i>Rend. Accad. Lincei</i> , XXX , 1921, p. 472.
.009	1.6371	1.6436 F	1.6346 C	Barite	A. Arzruni:-	<i>Zeit. Kryst.</i> , I , 1877, p. 102.
.009	1.6455 ±	1.6527 F	1.6426 C	Tourmaline (Yellow)	K. Schlossmacher:-	<i>Cent. Min.</i> , 1919, p. 106.
.009	1.654	1.661 (480)	1.651 Li	Phenacite	Offret:-Groth:-	<i>Chem. Kryst.</i> , II , 1908, p. 247.
.009	1.6553	1.6606 (502)	1.6521 (688)	Euclase	L. Weber:-	<i>Zeit. Kryst.</i> , LVII , 1923, p. 407.
.009 ±	1.6596	1.6625 Tl	1.6557 Li	Sillimanite	L. J. Spencer:-	<i>Mineral. Mag.</i> , XIX , 1920, p. 107.

* Analysis given.

DISPERSION OF MINERALS

N, N ₀ or N _m				MINERAL	AUTHORITY	REFERENCE
F-C	D	Blue	Red			

Section 4. N _F N _C =.0095 to .0105						
.010	1.4839	1.4869 Tl	1.4808 Li	Sodalite	K. Feussner:-	<i>Zeit. Kryst.</i> , V, 1881, p. 581.
.010	1.5096	1.5180 bl.	1.5078 red	Petalite	A. Des Cloizeaux:-	<i>Mon. Mineral.</i> , II, 1874, p. 36.
.01 ±	1.5144	1.518 Tl	1.5117 Li	Northupite*	J. H. Pratt:-	<i>Am. Jour. Sci.</i> , II, 1896, p. 123.
.010 ±	1.5734	1.5771 E	1.5703 B	Beryl	A. Schrauf:-	<i>Sitz. Akad. Wiss. Wien</i> , XLII, 1860, p. 116.
.0095	1.583	1.5895 F	1.580 C	Anorthite	S. Tsuboi:-	<i>Mineral. Mag.</i> , XX, 1922, p. 108.
.01 ±	1.5870	1.5902 Tl	1.5831 Li	Muscovite	R. C. Sabot:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 420.
.010	1.5921	1.5974 (502)	1.5883 (668)	Colemanite	L. Weber:-	<i>Zeit. Kryst.</i> , LX, 1924, p. 164.
.010 ±	1.6170	1.6202 green	1.6142 red	Hemimorphite	Lang:-	<i>Sitz. Akad. Wiss. Wien.</i> , XXXVII, 1859, p. 379.
.01 ±	1.6342	1.6383 Tl	1.6283	Danburite	C. Hintze:-	<i>Zeit. Kryst.</i> , VII, 1883, p. 302.
.01 ±	1.6348	1.6418 F	1.6318 C	Tourmaline*	K. Becht:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 336.

.010 ±	1.6382 (578)	1.6452 (492)	1.6345 (691)	Apatite	A. Ehringhaus:—	<i>N. Jahrb. Min., Bl. Bd.,</i> XLI , 1917, p. 360.
.01 ±	1.6577	1.6611 TI	1.6542 Li	Sillimanite	G. Melzer:—	<i>Zeit. Kryst., XXXIII</i> , 1900, p. 253.
.010 ±	1.6653	1.6681 TI	1.6617 Li	Spodumenite*	L. Duparc <i>et al.</i> :—	<i>Zeit. Kryst., LII</i> , 1913, p. 299.
.010	1.6717	1.6785 (475)	1.6679 (667)	Parisite	F. Quercigh:—	<i>Zeit. Kryst., LV</i> , 1915, p. 273.
.01 ±	1.7201	1.7272 blue	1.7171 red	Spinel	M. Bauer:—	<i>N. Jahrb. Min.</i> , 1895, I, p. 282.
.01 ±	1.722	1.729 blue	1.719 red	Diasporite	A. Des Cloizeaux:—	Dana:— <i>System Min.</i> , 1892, p. 246.
.01 ±	1.7287	?	1.7250 Li	Ganophyllite	A. Hamberg:—	<i>Geol. För. Förh., XII</i> , 1890, p. 586.

Section 5. $N_F N_C = .0105$ to .0115

.011	1.4904	1.4983 F	1.4872 C	Sylvite	K. Spangenberg:—	<i>Zeit. Kryst., LVII</i> , 1922, p. 494.
.011	1.5220	1.5252 TI	1.5189 Li	Microcline*	L. Duparc <i>et al.</i> :—	<i>Zeit. Kryst., LII</i> , 1913, p. 294.
.0115	1.5662	1.5764 (471)	1.5617 (706)	Brucite	A. Ehringhaus:—	<i>N. Jahrb. Min., Bl. Bd.,</i> XLI , 1917, p. 371.
.011 ±	1.5702	1.5737 E	1.5662 B	Beryl	A. Schrauf:—	<i>Sitzb. Akad. Wiss. Wien.,</i> XIII , 1860, p. 116.

* Analysis given.

DISPERSION OF MINERALS

N, N ₀ or N _m				MINERAL	AUTHORITY	REFERENCE
	D	Blue	Red			
.0113	1.5903	1.5937 Tl	1.5869 Li	Scapolite*	R. Brauns:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 214.
.011	1.6455	1.6532 F	1.6421 C	Tourmaline*	K. Becht:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 336.
.0106	1.6776	1.6850 F	1.6744 C	Diopside	H. Dufet:-	<i>Bull. Soc. Fr. Min.</i> , X, 1887, p. 214.
.0113	1.7153	1.724 F	1.7107 C	Clinozoisite*	F. Zambonini:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 317.
.0114	1.7219	1.7303 F	1.7189 C	Cyanite	E. Taubert:-	<i>Zeit. Kryst.</i> , XLIV, 1908, p. 314.
.011 ±	1.7470	1.7503 Tl	1.7431 Li	Chrysoberyl	G. Melzer:-	<i>Zeit. Kryst.</i> , XXXIII, 1900, p. 240.
.0106	1.7684	1.7759 F	1.7652 C	Corundum	G. Melzer:-	<i>Zeit. Kryst.</i> , XXXV, 1902, p. 561.
.011	1.8142	1.8172 Tl	1.8088 Li	Spessartite*	R. C. Sabot:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 224.

Section 6. N_F-N_C= .0115 to .0125

.012 ±	1.526	1.536 bl.	1.526 red	Wavellite
				A. Des Cloizeaux:-
				<i>Man. Mineral.</i> , II, 1893, p. 455.

.012 ±	1.539	1.5345 B	1.5435 E	Mellite	A. Schrauf:—	Dana:— <i>System Min.</i> , 1892, p. 994.
.0115	1.5662	1.5764 (471)	1.5617 (706)	Brucite	A. Ehrlinghaus:—	<i>N. Jahrb. Min., Bl. Bd.</i> , XII, 1917, p. 371.
.012 ±	1.5704	1.5748 E	1.5604 B	Beryl	A. Schrauf:	<i>Sitz. Akad. Wiss. Wien.</i> , XLII, 1860, p. 116.
.012 ±	1.5948	?	1.5909 red	Leucophanite	W. C. Broegger:—	<i>Zeit. Kryst.</i> , XVI, 1890, p. 246.
.012 ±	1.5956	1.5992 Tl	1.5922 Li	Clinoclhorite	C. Pulfrich:	<i>Wied. Ann.</i> , XXX, 1887, p. 501.
.012 ±	1.6126	1.6161 Tl	1.6097 Li	Meliphanite*	W. C. Broegger:—	<i>Zeit. Kryst.</i> , XVI, 1890, p. 279.
.012 ±	1.6515	1.6549 Tl	1.6485 Li	Tourmaline*	R. C. Sabot:	<i>Zeit. Kryst.</i> , LVII, 1922, p. 339.
.0117	1.6600	1.6671 F	1.6554 C	Sillimanite	E. Taubert:—	<i>Zeit. Kryst.</i> , XLIV, 1908, p. 314.
.012 ±	1.6616	1.6653 Tl	1.6594 Li	Monticellite*	S. L. Penfield:—	<i>Am. Jour. Sci.</i> , I, 1896, p. 134.
.012 ±	1.667	1.675 bl.	1.663 red	Boracite	A. Des Cloizeaux:—	<i>Mon. Mineral.</i> , II, 1874, p. 3.
.0117	1.6697	1.6780 F	1.6663 C	Olivine*	E. Ernst:—	<i>N. Jahrb. Min., Bl. Bd.</i> , LII, 1925, p. 133.
.0123	1.6810	1.6912 (471)	1.6748 (706)	Aragonite	B. Marbach:—	<i>Zeit. Kryst.</i> , LVI, 1921, p. 233.
.012 ±	1.682	1.686 gr.	1.678 red	Pyrosmalite	G. Flink:—	<i>Zeit. Kryst.</i> , LVII, 1922, p. 425.

* Analysis given.

DISPERSION OF MINERALS

N, N ₀ or N _m				MINERAL	AUTHORITY	REFERENCE
F-C	D	Blue	Red			
.012 ±	1.688	1.692 Tl	1.684 Li	Triphylite*	S. L. Penfield:—	<i>Am. Jour. Sci.</i> , CL , 1895, p. 387.
.012	1.6935	1.6965 Tl	1.6895	Rhodizite*	Duparc, <i>et al.</i> :—	<i>Bull. Soc. Fr. Min.</i> , XXXIV , 1911, p. 136.
.012 ±	1.705	1.709 Tl	1.701 Li	Pyrope (pure)	H. Philipsborn:—	<i>Abh. Sachs. Akad. Wiss.</i> , XL , 1928, No. III.
.0124	1.7125	1.721 F	1.7086 C	Olivine *	F. S. Starrabba:—	<i>Zeit. Kryst.</i> , LVI , 1921, p. 456.
.012	1.7188	1.7227 Tl	1.7153 Li	Spinel	G. Melczer:—	<i>Zeit. Kryst.</i> , XXII , 1900, p. 260.
.0125	1.7450	1.7538 F	1.7413 C	Staurolite*	F. Hörner:—	<i>Zeit. Kryst.</i> , LVIII , 1922, p. 311.
.012 ±	1.7634	1.7725 (477)	1.7599 C	Epidote*	M. Goldschlag.	<i>Tsch. Min. Pet. Mit.</i> , XXXIV , 1917, p. 47.
.012 ±	1.6616	1.6653 Tl	1.6594 Li	Monticellite*	S. L. Penfield	<i>Am. J. Sci.</i> , I , 1896, p. 134.
.012 ±	1.6515	1.6549 Tl	1.6485 Li	Tourmaline*	R. C. Sabot	<i>Zeit. Kr.</i> , LVIII , 1922, p. 339.

Section 7. N_F-N_C= .0125 to .0135

.013 ±	1.474	1.483 bl.	1.470 red	Thénardite	A. Des Cloizeaux:—	Dana:— <i>System Min.</i> , 1892, p. 895.
.0127	1.5442	1.5532 F	1.5405 C	Halite	S. P. Langley:—	<i>Am. Jour. Sci.</i> , XXX , 1885, p. 477.

.013 ±	1.5698	1.5749 E	1.5665 C	Scapolite*	A. Lacroix:	C. R., CLXIX , 1919, p. 261.
.0127	1.5818	1.5863 E	1.5777 B	Beryl	A. Schrauf:—	<i>Sitz. Wiss. Wien</i> , XLII , 1860, p. 116.
.013 ±	1.59 ±	1.593 bl.	1.580 red	Clinoclhorite	G. Tschermak:—	<i>Sitz. Akad. Wiss. Wien</i> , XCIX , 1890, p. 174; C , 1891, p. 29.
.013	1.6573	1.6701 F	1.6553 (6.33)	Dioplasite*	E. Quercigh:	<i>N. Jahrb. Min.</i> , 1916 , I, p. 159.
.0134	1.6584	1.6678 F	1.6544 C	Calcite	A. Ehringhaus:—	<i>N. Jahrb. Min., Bl. Bd.</i> , XLIII , 1920, p. 602.
.013 ±	1.659	1.670 bl.	1.657 red	Forsterite	A. Des Cloizeaux:—	<i>Hintze: Hdb. Min.</i> , II , 1897, p. 4.
.0132	1.6726	1.6819 F	1.6687 C	Hardystonite*	K. H. Degen:—	<i>Sitz. Akad. Wiss. Heidel-berg</i> , 1919 , A14.
.0135	1.6799	1.6893 F	1.6758 C	Dolomite*	P. Koller:—	<i>N. Jahrb. Min., Bl. Bd.</i> , XLII , 1918, p. 457.
.0128	1.6810	1.6900 F	1.6772 C	Aragonite	A. Mülheims:—	<i>Zeit. Kryst.</i> , XIV , 1888, p. 202.
.013 ±	1.685	1.691 bl.	1.678 red	Axinite	A. Des Cloizeaux	<i>Mon. Mineral.</i> , I , 1862, p. 515.
.0132	1.7008	1.7102 F	1.6970 C	Olivine*	E. Ernst:—	<i>N. Jahrb. Min., Bl. Bd.</i> , LII , 1925, p. 133.
.0132	1.7039	1.7138 F	1.7006 C	Augite*	E. A. Wülfing:—	<i>Tsch. Min. Pet. Mit.</i> , XV , 1896, p. 29.
.0127	1.7170	1.7255 F	1.7128 C	Clinozoisite	T. Siliprandi:—	<i>Zeit. Kryst.</i> , LVII , 1922, p. 325.

* Analysis given.

DISPERSION OF MINERALS

N, N ₀ or N _m				MINERAL	AUTHORITY	REFERENCE
F-C	D	Blue	Red			
.013	1.7378	1.7494 (471)	1.7313 (706)	Periclasite Grossularite	O. Westphal:-	<i>Cent. Min.</i> , 1913, p. 516.
.013	1.7438	1.7480 Tl	1.7394 Li		E. A. Wülfing:-	H. Rosenbusch:- <i>Mikr. Phys.</i> , p. 18.
.013 ±	1.7444	1.7476 Tl	1.7389 Li	Pyrope Staurolite	B. Jezek:-	<i>Min. Abst.</i> , II, 1923, p. 139.
.0127	1.7496	1.7585 F	1.7458 C		F. Hörner:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 312.
.013 ±	1.7926	1.7980 green	1.7886 red	Thortveitite	J. Schetelig:-	<i>Norsk. Geol. Tids.</i> , VI, 1922, p. 233; <i>Vidensk. Skr.</i> , 1922, p. 51.
.013 ±	1.8038	1.8078 F	1.7981 C	Spessartite*	R. C. Sabot:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 224.

Section 8. N_F-N_C= .0135 to .0155

.0138	1.5554	1.5599 Tl	1.5513 Li	Whewellite	B. Jezek:-	<i>Zeit. Kryst.</i> , LIV, 1915, p. 192.
.014 ±	1.60 ±	1.604 violet	1.590 red	Vivianite	A. Des Cloizeaux:-	Dana: <i>System Min.</i> , 1892, p. 814.
.014 ±	1.6536	1.6576 Tl	1.6518 Li	Tourmaline	R. C. Sabot:-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 390.
.0136	1.6585	1.6682 F	1.6545 C	Calcite	A. Schrauf:-	<i>Zeit. Kryst.</i> , XI, 1885, p. 5.

.014 ±	1.6682	1.6727 Tl	1.6627 Li	Rinkite	Osann :-	Rosenbusch :- <i>Mikr. Phys.</i> , 1905, p. 292.
.0137	1.6698	1.6795 F	1.6658 C	Justite*	K. H. Degen :-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 104.
.0142	1.6712	1.6816 F	1.6674 C	Hardystonite*	K. H. Degen :-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 104.
.0139	1.685 ±	1.6918 bl.	1.6779 red	Axinite	A. Des Cloizeaux :-	<i>Man. Mineral.</i> , I, 1862, p. 515.
.014	1.6920	1.6965 Tl	1.6872 Li	Dolomite*	M. Born :-	<i>N. Jahrb. Min., Bl. Bd.</i> , V, 1887, p. 4.
.0136	1.7172	1.7277 (477)	1.7132 C	Clinzoisite	M. Goldschlag :-	<i>Tsch. Min. Pet. Mit.</i> , XXXIV, 1917, p. 23.
.015 ±	1.7207	1.7244 Tl	1.7166 Li	Xenotime	E. H. Kraus :-	<i>Zeit. Kryst.</i> , XXXIV, 1901, p. 268.
.014 ±	1.726	1.7305 Tl	1.721 C	Pyroxene* (Hess)	P. Eskola :-	<i>Jour. Geol.</i> , XXX, 1920, p. 276.
.014	1.7375	1.7475 F	1.7335 C	Periclasite (art.)	H. E. Merwin :-	<i>Am. Jour. Sci.</i> , CXCVIII, 1919, p. 82.
.014 ±	1.7439	1.7479 Tl	1.7396 Li	Pyrope	E. A. Wülfing :-	Rosenbusch :- <i>Mikr. Phys.</i> , 1905, p. 18.
.014	1.7441	1.7482 Tl	1.7399 Li	Grossularite*	H. Philipsborn :-	<i>Abh. Sachs. Akad. Wiss.</i> , XI, 1928, No. III.
.015 ±	1.7964	1.8013 Tl	1.7910 Li	Almandite*	H. Philipsborn :-	<i>Abh. Sachs. Akad. Wiss.</i> , XI, 1928, No. III.
.015 ±	1.8145	1.8195 Tl	1.8090 Li	Spessartite	R. C. Sabot :-	<i>Zeit. Kryst.</i> , LVII, 1922, p. 224.

* Analysis given.

DISPERSION OF MINERALS

N, N ₀ or N _m				MINERAL	AUTHORITY	REFERENCE
F-C	D	Blue	Red			
Section 9. N _F -N _C = .0155 to .0195						
.0187	1.5056	1.5191 F	1.5004 C	Niter	A. Ehringhaus:-	N. Jahrb. Min., Bl. Bd., XLIII, 1920, p. 602.
.018	1.546	1.559 F	1.541 C	Copiapite (art.)	H. E. Merwin:-	Jour. Am. Chem. Soc., XLIV, 1922, p. 1965.
.019 ±	1.550	1.564 F	1.545 C	Rhomboclasite (art.)	H. E. Merwin:-	Jour. Am. Chem. Soc., XLIV, 1922, p. 1965.
.019	1.5874	1.5954 E	1.5793 B	Nitratite	A. Schrauf:-	Groth: Chem. Kryst., II, 1908, p. 72.
.016 ±	1.5886	1.5930 Tl	1.5836 Li	Rinneite	H. E. Boeck:	N. Jahrb. Min., 1909, II, p. 19.
.0167	1.6426	1.6529 F	1.6380 C	Salammonite	Graulich:	Hintze: Hdb. Min., I, 1915, p. 2255.
.017	1.6494	1.6545 Tl	1.6460 Li	Datolite*	O. Luedcke:	Hintze: Hdb. Min., II, 1898, p. 168.
.016	1.6893	1.7012 (481)	1.6847 C	Willemite	A. Ehringhaus:	Zeit. Kryst., LVIII, 1925, p. 460.
.017 ±	1.7202	1.7254 Tl	1.7173 Li	Trimerite*	W. C. Broegger:	Zeit. Kryst., XVIII, 1891, p. 373.
.016 +	1.7366	1.7411 Tl	1.7340 Li	Hedenbergite	E. A. Wülfing:-	Beil. Ken. Pyroxen, 1891.

.0169	1.7422	1.7551 (477)	1.7572 C	Epidote*	M. Goldschlag:	<i>Tsch. Min. Ped. Mit.</i> , XXXIV, 1917, p. 23.
.018 ±	1.7456	1.7508 Tl	1.7396 Li	Pyrope	B. Jezek:—	<i>Min. Abst.</i> II, p. 139.
.016 ±	1.746	1.755 blue	1.739 red	Lilbetheinite	A. Des Cloizeaux:—	<i>Dana:—System Min.</i> , 1892, p. 78.
.017 ±	1.7626	1.7676 Tl	1.7575 Li	Grossularite	E. A. Wülfing:—	Rosenbusch:— <i>Mikr. Phys.</i> , 1905, p. 18.
.0165	1.7912 (578)	1.8093 (436)	1.7877 (620)	Monazite	K. Busz:—	<i>N. Jahrb. Min., Bl. Bd.</i> , XXXIX, 1914, p. 482.
.019 ±	1.8105	1.8158 Tl	1.8050 Li	Spessartite	F. A. Wülfing:—	Rosenbusch:— <i>Mikr. Phys.</i> , 1905, p. 18.
.017	1.8488	1.8623 F	1.8436 C	Smithsonite*	E. D. Mountain:—	<i>Mineral. Mag.</i> , XXI, 1926, p. 51.
.018 ±	1.85 ±	1.864 blue	1.846 red	Caledonite	A. Des Cloizeaux:—	<i>Dana:—System Min.</i> , 1892, p. 924.

Section 10. N_F-N_C= .0195 to .0245

.021	1.624	1.638 F	1.617 C	Metatorbernite	N. L. Bowen:—	<i>Am. Jour. Sci.</i> , CXCVIII, 1919, p. 195.
.0196	1.6818	1.6951 F	1.7655 C	Thorite	M. Albis:—	<i>Rend. Accad. Lincei Rom.</i> , XXX, 1920, p. 472.
.022 ±	1.7418	1.7525 Tl	1.738 Li	Garnet	A. Laitakari:—	<i>Zeit. Kryst.</i> , LVII, 1922, p. 229.

* Analysis given.

DISPERSION OF MINERALS

N, N ₀ or N _m					MINERAL	AUTHORITY	REFERENCE
F-C	D	Blue	Red				
.02 ±	1.755	?	1.748 Li		Arsenolite	A. Des Cloizeaux:-	Dana:- <i>System Min.</i> , 1892, p. 198.
.0204	1.7788	1.7937 F	1.7732 C		Allactite	G. Aminoff:-	<i>Geol. För. Förh.</i> , XLIII, 1921, p. 40.
.021 ±	1.786	1.794 Tl	1.780 Li		Tephroite*	N. H. Magnusson:-	<i>Geol. För. Förh.</i> , XL, 1918, p. 611.
.02 ±	1.807	1.8196 F	?		Gahnite*	P. Eskola:-	<i>Geol. För. Förh.</i> , XXXVI, 1914, p. 25.
.021	1.8384	1.8449 Tl	1.8318 Li		Uvarovite	E. A. Wulhing:-	Rosenbusch:- <i>Mikr. Phys.</i> , 1895, p. 18.
.024 ±	1.8724	1.8799 Tl	1.8693 Li		Siderite*	A. Hutchinson:-	<i>Mineral Mag.</i> , XIII, 1903, p. 209.
.022 ±	1.9091	1.9158 Tl	1.9018 Li		Titanite*	K. Busz:-	<i>N. Jahrb. Min., Bl. Bd.</i> , V, 1887, p. 334.
.021	1.9200	1.9344 (475)	1.9124 C		Scheelite (art.)	A. Zambonini:-	<i>Zeit. Kryst.</i> , LIX, p. 476.
.023	1.9251	1.9416 E	1.9184 C		Zircon	W. F. Eppler:-	<i>N. Jahrb. Min., Bl. Bd.</i> , LV, 1927, p. 415.

Section 11. N_F-N_C= .0245 to .0295

.026	1.652	1.670 F	1.644 C	Mullite (art.)	W. Eitel:-	<i>Zeit. Anorg. Chem.</i> , LXXXVIII, p. 173.

.027	1.664	1.672 Tl	1.657 Li	Strontianite	L. Buchucker:—	Groth: <i>Chem. Kryst.</i> , II, 1908, p. 209.
.0262	1.7569	1.7666 (511)	1.7432 C	Epidote*	M. Goldschlag:—	<i>Tsch. Min. Pd. Mit.</i> , XXXIV, 1917, p. 43.
.027	1.7714	1.7796 Tl	1.7445 Li	Grossularite	E. A. Wülfing:—	Rosenbusch: <i>Mikr. Phys.</i> , 1905, p. 18.
.027	1.812	1.831 F	1.803 (700)	Beckelite	S. Kreutz:—	<i>Zeit. Kryst.</i> , LVI, 1921, p. 634.
.026	1.8376	1.8554 (492)	1.8310 C	Roméite	H. Rose:—	<i>Cent. Min.</i> , 1919, p. 268.
.026	1.8827	1.9002 (492)	1.8739 (672)	Anglesite	A. Ehringhaus and H. Rose:—	<i>Zeit. Kryst.</i> , LVIII, 1925, p. 460.
.0251	2.4175	2.4354 F	2.4103 C	Diamond	E. A. Wülfing:—	<i>Tsch. Min. Pd. Mit.</i> , XV, 1895, p. 65.

Section 12. $N_F - N_G \equiv .0295$ to $.0495$

.03 ±	$N_g = 1.7876$ $N_p = 1.7431$	1.8025 green 1.7580 green	1.7785 red 1.7320 red	Lorenzenite	G. Flink:—	<i>Med. Grön.</i> , XIV, 1898, p. 250; XXIV, 1901, p. 130.
.035 ±	1.7990	1.8096 Tl	1.7929 Li	Acrmite	E. A. Wülfing:—	<i>Beil. Ken. Pyroxen</i> , 1891, p. 65.
.04 ±	1.895 ±	1.907 Tl	1.883 Li	Andradite (pure)	H. Philipsborn:—	<i>Abh. Sachs. Akad. Wiss.</i> , XL, 1928, No. III.
.033 ±	1.9048	1.9162 Tl	1.8958 Li	Titanite*	K. Busz:—	<i>N. Jahrb. Min., Bl. Bd.</i> , V, 1887, p. 338.
.04 ±	1.974 (570)	1.983 (533)	1.959 (667)	Powellite (art.)	F. Zambonini:—	<i>Bull. Soc. Fr. Min.</i> , XXVIII, 1915, p. 206.

* Analysis given.

DISPERSION OF MINERALS

N, N ₀ or N _m				MINERAL	AUTHORITY	REFERENCE
F-C	D	Blue	Red			
.0373	1.9986	2.0247 F	1.9874 C	Cassiterite	H. Baumhauer:-	<i>Zeit. Kryst.</i> , XLVII , 1909, p. 1.
.046 ±	2.061	2.096 F	2.050 C	Pyromorphite*	H. L. Bowman:-	<i>Mineral. Mag.</i> , XIII , 1903, p. 324.
.049 ±	2.063	2.097 F	2.048 C	Chlorargyrite	W. Wernicke:-	<i>Hintze-Hdb. Min.</i> , I , 2, 1915, p. 2279.
.035 ±	2.0763	2.1549 H	2.0595 B	Cerussite	A. Schrauf:-	<i>Sitz. Akad. Wiss. Wien.</i> , XLII , 1860, p. 120.
.04 ±	2.087	?	2.073 red	Senarmonite	A. Des Cloizeaux:-	Dana:- <i>System Min.</i> , 1892 , p. 198.
.045 ±	2.18	2.19 green	2.16 red	Manganosite	W. E. Ford:-	<i>Am. Jour. Sci.</i> , XXXVIII , 1914, p. 502.
Section 13. N _F -N _C = .0495 to .0995						
.066	1.816	1.865 F	1.799 C	Carphosiderite (art.)	H. E. Merwin:-	<i>Jour. Am. Chem. Soc.</i> , XLIV , 1922, p. 1965.
.057 ±	1.9733	1.9909 Tl	1.9556 C	Calomel	H. Dufet:-	<i>Bull. Soc. Fr. Min.</i> , XXI , 1898, p. 90.
.0497	1.9995	2.0363 F	1.9866 C	Pyrochlorite	S. Kreutz:-	<i>Zeit. Kryst.</i> , LXI , 1925, p. 347.

.07	2.013	2.039 (530)	1.994 C	Zincite*	H. Berman:	<i>Am. Mineral.</i> , XII , 1927, p. 168.
.07 ±	2.0377	2.0586 Tl	2.0171 Li	Sulphur	A. Schrauf:—	<i>Zell. Kryst.</i> , XVIII , 1891, p. 157.
.05 ±	2.059	2.094 F	2.044 C	Chlorargyrite	W. Wernicke:—	<i>Hintze-Hdb. Min.</i> , I , 2, 1915, p. 2279.
.08 ±	2.254	2.316 F	2.234 C	Bromyrite	W. Wernicke:—	<i>Hintze-Hdb. Min.</i> , I , 2, 1915, p. 2299.
.091	2.2949	2.3634 F	2.2725 C	Finnemanite*	C. Aminoff:—	<i>Geol. För. Förh.</i> , XIV , 1923, p. 160.
.08 ±	2.356	?	2.330 Li	Wurtzite (art.)	H. E. Merwin:—	<i>Am. Jour. Sci.</i> , XXXIV , 1912, p. 383.
.09	2.368 ±	2.398 Tl	?	Sphalerite (pure)	H. E. Merwin:—	<i>Am. Jour. Sci.</i> , XXXIV , 1912, p. 383.
.09 ±	2.4039	2.4342 Tl	2.375 Li	Stibiotantalite*	Penfield and Ford:	<i>Am. Jour. Sci.</i> , XXII , 1906, p. 61.
.064	2.654	2.700 F	2.633 Li	Moissanite (art.)	H. E. Merwin:—	<i>Jour. Wash. Acad. Sci.</i> , VII , 1917, p. 445.

Section 14. $N_F N_C = .0995$ to .195

.126 ±	2.182	2.279 F	2.153 C	Iodyrite	W. Wernicke:—	<i>Hintze-Hdb. Min.</i> , I , 2, p. 2308.
.12 ±	2.30	?	2.26 Li	Brannerite*	Hess and Wells:—	<i>Jour. Frank. Inst.</i> , CLXXXIX , 1920, p. 225.
.13 ±	2.346	2.385 Tl	2.313 Li	Marshite	L. J. Spencer:—	<i>Mineral. Mag.</i> , XIII , 1901, p. 38.

* Analysis given.

DISPERSION OF MINERALS

N, N ₀ or N _m				MINERAL	AUTHORITY	REFERENCE
F-C	D	Blue	Red			
.18 ±	2.39	For Ng:- Na-Li = .06		Goethite	H. E. Merwin:-	<i>Am. Jour. Sci.</i> , XLVII , 1919, p. 311.
.134	2.4055	2.4611 (518)	2.3724 C	Wulfenite	A. Ehringhaus:-	<i>N. Jahrb. Min., Bl. Bd.</i> , XLIII , 1920, p. 568.
.15 ±	2.43	?	2.38 Li	Sphalerite* (with 17% FeS)	H. E. Merwin:-	<i>Am. Jour. Sci.</i> , XXXIV , 1912, p. 383.
.12 ±	2.4804	?	2.4408 Li	Pyrophanite*	A. Hamberg:-	<i>Geol. För. Förh.</i> , XII , 1890, p. 598.
.142	2.5618	2.6586 (492)	2.5183 Li	Octahedrite	A. Ehringhaus:-	<i>N. Jahrb. Min., Bl. Bd.</i> , XLI , 1917, p. 376.
.13 ±	2.5856	?	2.5418 Li	Brookite	E. A. Wülfing:-	Rosenbusch:- <i>Mikr. Phys.</i> , 1905, p. 123.
.158 ±	2.6158	2.6725 T ¹	2.5671 Li	Rutile	C. Bärwald:-	<i>Zeit. Kryst.</i> , VII , 1883, p. 168.

Section 15. N_F-N_C > .195

.21 ±	2.23	2.39 blue	2.18 red	Bunsenite	A. Kundt:-	<i>Sitz. Akad. Wiss. Berlin</i> , 1888, pp. 255, 1387.
.23 ±	1.47 ±	?	2.395 Li	Sphalerite* (with 28% FeS)	H. E. Merwin:-	<i>Am. Jour. Sci.</i> , XXXIV , 1912, p. 383.

.23 ±	2.59 ±	2.688 green	2.552 red	Greenockite	Miller:—	Groth:— <i>Chem. Kryst.</i> , I, 1906, p. 150.
.55 ±	2.84	3.18 blue	2.63 red	Tenorite	A. Kundt:—	<i>Sitz. Akad. Wiss. Berlin</i> , 1888, pp. 255, 1387.
.4 ±	2.9051 (599)	?	2.8143 Li	Cinnabarite	H. Rose:—	<i>Cent. Min.</i> , 1912, p. 527.
.33 ±	3.088	?	2.979 Li	Proustite	Fizeau:	Groth:— <i>Chem. Kryst.</i> , II, 1908, p. 767.
.34 ±	3.176	?	3.063 C	Hutchinsonite*	G. F. H. Smith:—	<i>Mineral. Mag.</i> , XIV, 1907, p. 283.
.5 ±	3.22	?	3.042 C	Hematite	E. A. Wülfing:—	<i>Tsch. Min. Pel. Mit.</i> , XV, p. 71.

* Analysis given.

LOSEYITE—A NEW FRANKLIN MINERAL

L. H. BAUER, *Franklin, N. J.*

AND

HARRY BERMAN, *Harvard University.*

In the Stanton Collection of Franklin minerals recently acquired by the Harvard Mineralogical Museum, among other interesting specimens was one chiefly composed of the new mineral here to be described. This mineral is named loseyite in honor of Mr. Samuel R. Losey,* a native of Franklin and for many years, until his death, an ardent collector of the minerals occurring there.

Loseyite occurs as small lath-shaped bluish-white crystals more or less loosely grouped in radiating bundles in the cavities of a narrow vein composed chiefly of altered pyrochroite and sussexite. There are also present a few calcite crystals and a coating of hair-like minute needles which were identified as chlorophoenicite by optical tests. The untimely death of Mr. Stanton, who collected the specimen from an inaccessible part of the old mine workings, makes it impossible to state the location of the loseyite occurrence in the mine, since he made no record of the find.

CHEMICAL COMPOSITION

Loseyite is a basic carbonate of manganese and zinc in about equal molecular proportions, together with a slight amount of magnesium. The formula, deduced from the accompanying analysis, is $7\text{RO} \cdot 2\text{CO}_2 \cdot 5\text{H}_2\text{O}$, where $\text{R} = \text{Mn}^{11}:\text{Zn}:\text{Mg} = 5:4:1$. The formula may be written in basic form as $2\text{RCO}_3 \cdot 5\text{R}(\text{OH})_2$.

ANALYSIS OF LOSEYITE

	1.	2.	3.
MnO	34.94	.493	36.40
FeO	0.64	.009	
ZnO	32.77	.403	33.38
MgO	3.42	.085	
CO ₂	12.59 ^b	.286	12.90
H ₂ O	13.83 ^a	.768	
SiO ₂ (acid insoluble)	0.16	.003	13.18
Mn ₂ O ₃	1.03 ^c	.007	
Total	99.38		100.00

* Samuel R. Losey died about 23 years ago, aged about 73 years.

Weight of sample for analysis .4582 g.

a. Weight of separate sample .1215 g.

b. " " " " .1302 g.

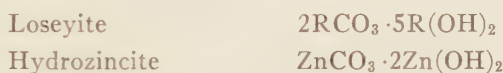
c. " " " " .0187 g.

1. Analysis by L. H. Bauer.

2. Molecular ratios omitting SiO_2 and Mn_2O_3 .

3. Calculated composition for $7 (\text{Mn}, \text{Zn}, \text{Mg})\text{O} \cdot 2\text{CO}_2 \cdot 5\text{H}_2\text{O}$.

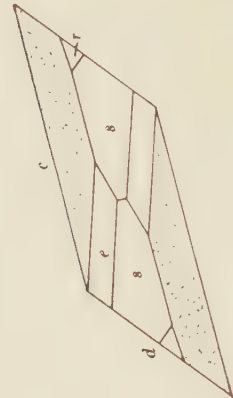
The formula here given for loseyite is analogous to that usually given for hydrozincite as is shown by comparing the two.



The data available on hydrozincite are not wholly satisfactory and further relationship between the two minerals cannot be definitely stated. It is certain, however, that loseyite, with its high manganese content deserves full species rank.

CRYSTALLOGRAPHY

The crystals of loseyite are monoclinic with elongation in the direction of the *b*-crystallographic axis. There were no crystals found which would yield really satisfactory goniometric measurements for crystallographic study. There were, however, some very minute lath-shaped crystals which could be used for approximate data. A number of these were measured, their size ranging from 0.5 to 0.2 mm. in length. The angles finally used were obtained from the two best of these minute crystals. Since the mineral is elongated in the direction of the *b*-axis, the measurements were made with this axis vertical. In the crystallographic table below, the angles and elements in this abnormal position [projection on (010)] are given, together with those calculated for the normal position. Figure 1 illustrates the habit of loseyite. The orthodome zone is striated parallel to the direction of elongation. The form $p(\bar{1}36)$ is the largest terminal form. Poor images were reflected from its faces, however, because they are etched. The prism $s(130)$ is small but gave brilliant reflection. The other forms noted had good reflection surfaces but their minute size prevented satisfactory readings.



Loseyite from Franklin, New Jersey

ANGLE TABLE—LOSEYITE

Side Pinacoid Position					Normal Position			
$p_0'' = 1.62; \gamma_0'' = 1.43; \mu = 85^\circ 30'$					$p_0 = .88$	$a = .70$	$\mu = 85^\circ 30'$	
					$q_0 = .62$	$c = .62$		
Miller Symbol	Observed ϕ	Averages ρ	Calculated ϕ ρ		Miller Symbol	Letter	Calculated ϕ ρ	
100	$85^\circ 30'$	$90^\circ 00'$	$85^\circ 30'$	$90^\circ 00'$	001	<i>c</i>	$90^\circ 00'$	$4^\circ 30'$
110	$47^\circ 09'$	$90^\circ 00'$	$46^\circ 03'$	$90^\circ 00'$	101	<i>d</i>	$90^\circ 00'$	$43^\circ 57'$
101	$85^\circ 30'$	$58^\circ 23'$	$85^\circ 30'$	$58^\circ 23'$	011	<i>e</i>	$7^\circ 16'$	$31^\circ 53'$
013	0°	$25^\circ 32'$	0°	$25^\circ 32'$	130	<i>s</i>	$25^\circ 32'$	$90^\circ 00'$
613	$-87^\circ \pm$	$74^\circ \pm$	$-86^\circ 04'$	$72^\circ 53'$	136	<i>p</i>	$-12^\circ 34'$	$17^\circ 34'$
$2 \cdot \bar{7} \cdot 14$	$-19^\circ \pm$	$35\frac{1}{2}^\circ \pm$	$-18^\circ 20'$	$36^\circ 20'$	$\bar{7} \cdot 14 \cdot 2$	<i>r</i>	$-34^\circ 55'$	$79^\circ 16'$

PHYSICAL PROPERTIES

The optical properties were determined in immersion media and are as follows: $\alpha = 1.637$; $\beta = 1.648$; $\gamma = 1.676$, measured in white light. Biaxial (+) positive; $2V = 64^\circ$, $Y = b$. $\rho > \nu$ weak.

The specific gravity of loseyite was determined by floating some crystals in clerici solution. The value thus obtained is 3.27. The value calculated from the composition according to the Gladstone & Dale formula is 3.25, indicating that the chemical formula is probably correct.

No prominent cleavage direction could be detected under the microscope. The hardness is about 3.

SUMMARY

Loseyite, occurs at Franklin, N. J.; named in honor of Samuel R. Losey, a collector of Franklin minerals. Composition, $2\text{RCO}_3 \cdot 5\text{R}(\text{OH})_2$; $\text{R} = \text{Mn}:\text{Zn}:\text{Mg} = 5:4:1$. Crystallography, Monoclinic, elongated parallel to *b*.

$$a:b:c = 0.70:1:0.62$$

$$\beta = 94^\circ 30'$$

$$p_0:q_0 = .88:.62$$

$$\mu = 85^\circ 30'$$

forms: $c(001)$, $e(011)$, $d(101)$, $s(130)$, $r(\bar{7}.14.2)$, $p(\bar{1}36)$.

Optical properties: Biaxial positive, $2V = 64^\circ$, $b = Y$, $\rho > \nu$, $\alpha = 1.637$, $\beta = 1.648$, $\gamma = 1.676$.

Physical properties: Specific gravity = 3.27. Hardness = $3 \pm$. Cleavage not detected. Color—bluish-white.

Association: Occurs with pyrochroite, sussexite, chlorophoenicite and calcite in a small vein in the ore at Franklin.

THE DETERMINATION OF THE CRYSTALLOGRAPHIC CONSTANTS IN THE TRICLINIC SYSTEM

A. L. PARSONS, *University of Toronto.*

The greatest pleasure that can be obtained from the measurement of a simple crystal and the calculation of its constants is in connection with a triclinic crystal. The system has been much abused and wrongfully so. When the calculation is made in connection with a gnomonic projection it becomes a very simple problem in solid trigonometry which offers absolutely no difficulty to a student who understands the rudiments of plane trigonometry. It is true that there are spherical triangles involved; in fact there are polar spherical triangles. The only characteristic about polar triangles that one needs to know is that the angles of one polar triangle are equal to 180° minus the opposite sides of the other polar triangle. When one of these triangles is solved the other is automatically solved. When the writer started the present paper it was his intention to give a graphic solution of the constants following the classical paper of Borgström and Goldschmidt,¹ which served as the model of his own paper on the same subject.² In proceeding with the work it became evident that a modification of the calculation offered many advantages in relating all the constants directly to two circle measurements so that the purpose of the present paper is to demonstrate a simple method of calculating the angular and linear constants of a triclinic crystal from measurements on the two circle goniometer.

For the calculation the forms (100), (010), (001), (011), ($\bar{1}01$), and ($\bar{1}11$) of copper sulphate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) are employed, using the ϕ and ρ values given in Goldschmidt's Winkeltabellen and using the orientation adopted there.

The determination of the following constants is given graphically and mathematically:

TABLE I.

α	$\sin (\nu - \phi_0) \cdot \tan \rho_0 = \cot \alpha$	av.
β	$\sin \phi_0 \cdot \tan \rho_0 = \cot \beta$	av.
γ	$\left\{ \begin{array}{l} \cot \rho_0 \cdot \cot \lambda = \sin \theta \\ \cot \rho_0 \cdot \cot \mu = \sin \kappa \\ \theta + \kappa = \gamma \end{array} \right\}$	
λ	$\cos \phi_0 \cdot \sin \rho_0 = \cos \lambda$	av. of γ_0'

¹ *Zeit. Kryst.*, 1906, 41, 163.

² *Am. Mineral.*, 5, pp. 190-194, 198-207.

$\mu \cos (\nu-\phi_0) \cdot \sin \rho_0 = \cos \mu$	av. of w_0'
ν measured direct	av.
$a = \frac{\{[\sin (\nu-\phi) \cdot \tan \rho^{011}] - [\sin (\nu-\phi) \tan \rho^{001}]\} \sin \alpha}{[(\sin \phi \cdot \tan \rho \text{ } \bar{1}01) - (\sin \phi \tan \rho^{001})] \sin \beta}$	av.
$b = 1$	
$c = [\sin (\nu-\phi) \tan \rho^{011}] - [\sin (\nu-\phi^{001}) \cdot \tan \phi^{001}] \sin \alpha$	av.
ϕ_0 measured direct ($=\phi$ for 001)	av.
ρ_0 measured direct ($=\rho$ for 001)	av.
$p_0 = p_0' \cos \rho_0$ (Gdt)	av.
$q_0 = q_0' \cos \rho_0$ (Gdt)	av.
$x_0' = \sin \phi_0 \tan \rho_0$	av.
$y_0' = \cos \phi_0 \tan \rho_0$	
$w_0' = \sin (\nu-\phi_0) \tan \rho_0$	av.
$u_0 = \cos (\nu-\phi_0) \tan \rho_0$	

The arithmetical calculation has been made in each case and yielded a perfect check for the angles and a maximum variation of three in the fourth decimal place for a and c , so that only the formulae employed are given.

In the graphical determination of the angles the angle point has been determined for the plane in which the angle lies in all cases. Where this angle point comes on the ground circle, in general no special mention is made of the fact inasmuch as the angle point for any plane passing through the pole lies on the ground circle.

Determination of α .

From the projection (fig. 1) it is evident that

$$\sin (\nu-\phi_0) \cdot \tan \rho_0 = \cot \alpha = \cot (180^\circ - \alpha)$$

$$\text{for} \quad \sin (\nu-\phi_0) = \frac{OA}{OF}$$

$$\text{and} \quad \tan \rho_0 = \frac{OF}{1}.$$

The average value of α may be obtained from all terminal faces as follows:

$$\sin (\nu-\phi) \cdot \tan \rho = \cot T = w' + qq_0' \cdot \sin \nu$$

$$\text{and} \quad \frac{w'}{1} = \cot \alpha.$$

Determination of $c:b$ (fig. 1), for forms (011), (111), ($\bar{1}11$), (211), etc.

$$\begin{aligned} \sin \nu - \phi \cdot \tan \rho &= \cot \xi \\ (\cot \xi - \cot \alpha) \cdot \sin \alpha &= \frac{c}{b} \end{aligned}$$

$$b = 1$$

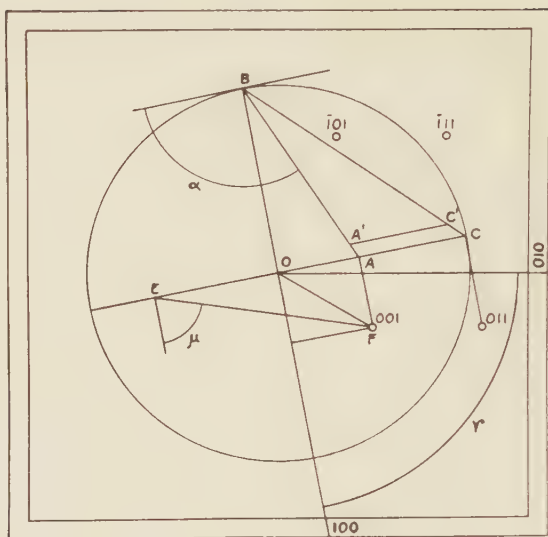


Figure 1.

Determination of μ (fig. 1).

From the projection it is also evident that

$$\cos (\nu - \phi_0) \cdot \sin \rho_0 = \cos \mu$$

Graphic Determination of μ .

Locate E the angle point of the zone 001-101. Then μ is the angle between 001 and 100.

Determination of ν (fig. 1).

For the determination of ν we have the direct measurement of the angle between the normals to the faces (100) and (010).

An average value of ν may be obtained from the rectangular co-ordinates of pairs of faces in the same zones as (010) and (100), respectively.

In the first case:

$$\frac{x_1 - x_2}{y_1 - y_2} = \tan 0^\circ$$

In the second case:

$$\frac{x_1 - x_2}{y_1 - y_2} = \tan \nu$$

If instead of $\tan 0^\circ$ we have a positive or negative value the corresponding angle must be subtracted from or added to the value of ν which is obtained from the second calculation.

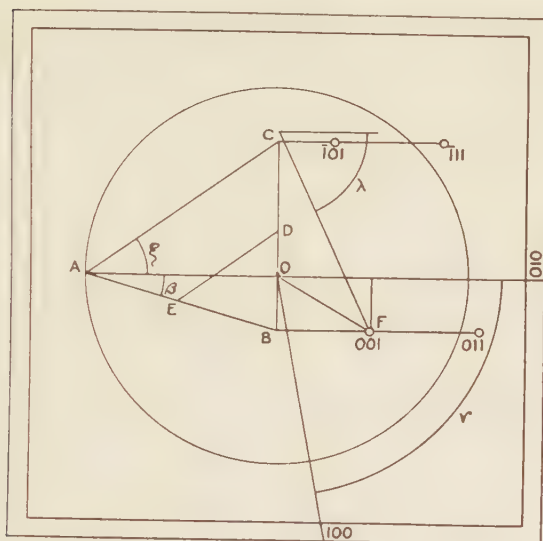


Figure 2.

Determination of β .

From the projection (fig. 2) it is evident that

$$\sin \phi_0 \cdot \tan \rho_0 = \cot \beta = \cot 180^\circ - \beta$$

for

$$\sin \phi_0 = \frac{BO}{OF}$$

and

$$\tan \rho_0 = \frac{OF}{1} = \frac{x_0'}{1}.$$

The average value for β may be obtained from all terminal faces as follows:

$$\sin \phi \cdot \tan \rho = \cot \Sigma = x_0' + p p_0' \cdot \sin \nu$$

and

$$\frac{x_0'}{1} = \cot \beta$$

Determination of λ (fig. 2).

It is also evident from the same figure that

$$\cos \phi_0 \cdot \sin \rho_0 = \cos \lambda = \cos(180^\circ - \lambda)$$

The average value of λ is obtained from the average value of y_0' .

Determination of $c:a$ and $a:b$ (fig. 2).

For the forms in the zone $(\bar{1}01)$ and $(\bar{1}11)$

$$\sin \phi \cdot \tan \rho = \cot \xi$$

$$\cot \xi - \cot \beta = \frac{CB}{OA}$$

$$\frac{CB}{OA} \cdot \sin \beta = \frac{CB}{AB} = \frac{c'}{a'} = \frac{c}{a}.$$

Taking $DB = C$ (determined in fig. 1) and drawing $DE \parallel AC$

then

$$\frac{DB}{EB} = \frac{c}{a}$$

and

$$EB = a.$$

By calculation

$$\frac{\frac{c}{b}}{\frac{c}{a}} = \frac{a}{b} = \frac{a}{1} = a.$$

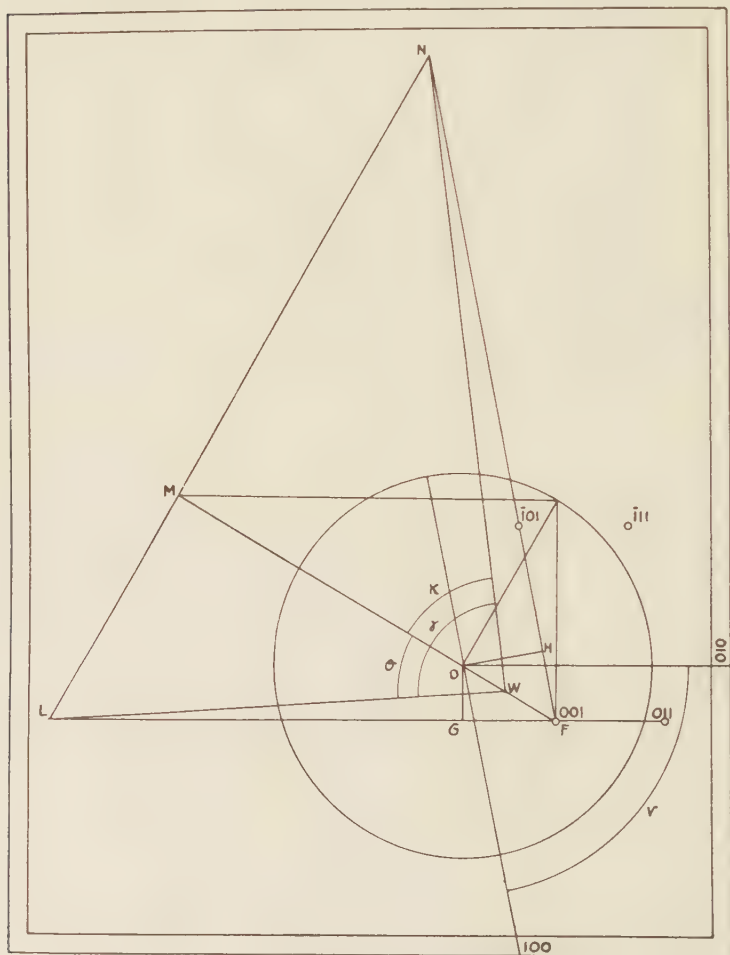


Figure 3.

Determination of γ (fig. 3).

In the plane of 001 we take the angles between the traces of the zone 001-010 and of the plane of the pole and 001= θ , and between the zone 001-100 and of the plane of the pole and 001= κ , then

$$\cot \rho_0 \cot \lambda = \sin \theta$$

and

$$\cot \rho_0 \cdot \cot \mu = \sin \kappa$$

and

$$\theta + \kappa = \gamma$$

Graphical determination of γ .

Locate M at 90° from F (001). Draw LN perpendicular to FM intersecting FN and FL at N and L . Determine the angle point W . Then $\angle NWL = \gamma$.

Determination of ϕ_0 , $\nu - \phi_0$, and ρ_0 .

In a former paper³ the equations are given that are necessary for obtaining the best average values for x_0' , y_0' , ρ_0 and ϕ_0 . From the average values of ϕ_0 and ν we obtain a good average of $(\nu - \phi_0)$.

CONCLUSION

The formulae that are given above furnish a simple means of determining the constants of a triclinic crystal with a high degree of accuracy. More good average values can be obtained than by previous methods. The readings on the goniometer are accurate only to the nearest minute. By using average values the constants in most cases can be obtained in seconds. The accuracy of the ratio $a:b:c$ depends upon accuracy of angles to seconds. With α , β and γ determined to the nearest minute there is an error in the fourth decimal place in the ratio $a:b:c$.

By the graphical methods shown a high degree of accuracy can be obtained both for the angular and linear constants.

The most important feature of the method lies in the fact that the results of two circle measurements of crystals can be compared with the constants that have been obtained by other methods without tedious calculation. In general the accuracy of the graphical solution is sufficient.

The methods shown here for the general case are readily employed for the special cases of the other crystal systems.

³ *Am. Mineral.*, 5, pp. 204, 205 and 207.

NOTES AND NEWS

NOTE ON HYDROPHILITE.

CHESTER B. SLAWSON, *University of Michigan.*

In running a number of fusions upon anhydrous calcium chloride it was found impossible to check the optical data recorded for this material in Larsen's Tables.¹ Anhydrous calcium chloride occurs in nature as the mineral hydrophilite but no optical determinations have been made upon the mineral itself. The data given by Larsen were obtained upon artificial melts which were cooled, crushed while hot, and immersed immediately in oil. He states that the substance is "uniaxial positive, $\omega=1.605$, $\epsilon=1.615$. It shows a perfect prismatic cleavage and polysynthetic twinning parallel to the c axis. This material inverts while in oil to an isotropic form, in which $n=1.52$, and this material is filled with and bordered by a bi-refracting material in shreds that has a lower index of refraction."

The first part of these observations were easily verified but no tendency to invert to the isotropic form was observed, even after being immersed in the index liquids for a period of thirty days. Another series of melts were sealed in test tubes, in contact with dry air, for thirty days without inverting. The twinning observed by Larsen was very characteristic and in many basal sections resembled the twinning of microcline. The extinction is symmetrical to the two sets of twinning lamellae and in those cases in which the lamellae were wide, positive biaxial interference figures were obtained with an optic angle of moderate size. The values determined for the indices of refraction were: $\alpha=1.600$, $\beta=1.605$, $\gamma=1.613$, all ± 0.003 . Described on the basis of its pseudo-tetragonal crystallization, the twinning lamellae are parallel to the first order prisms and the optic planes parallel to the second order prisms. The resultant interference figure in all cases except those few which have wide twinning lamellae, is uniaxial positive. Because of the perfect prismatic cleavage interference figures are not commonly observed. The series of index liquids used in these determinations consisted of mixtures of paraffin oil and alpha monobromnaphthalene.

Later while working with a series of index liquids composed of mixtures of turpentine and cinnamon oil, the material began to invert to an isotropic form as Larsen had observed. An examination of the literature of calcium chloride showed that anhydrous calcium chloride forms double compounds with many organic reagents. J. E. Heindl² prepared a series of alcoholates with the general formula $\text{CaCl}_2 \cdot 3\text{ROH}$, where R represents the various members of the methane series. These compounds were described as calcium chloride with "alcohol of crystallization." A. Lieben³ prepared a series of double compounds of calcium chloride with the fatty acids. It is probable that the "inversion" of calcium chloride is due to a reaction of this type with one of the components of the index liquids used. The mean value of the indices of refraction of anhydrous calcium chloride calculated from the specific refractive energies⁴ is 1.599 which agrees closely with the determined values.

¹ Larsen, E. S., The Microscopic determination of the monopaque minerals. *U.S.G.S., Bull.* 679, p. 89, 1921.

² and ³ Mellor, J. W., A comprehensive treatise on inorganic and theoretical chemistry. Vol. 3, p. 712, 1923.

⁴ Larsen, E. S., *op. cit.*, p. 31.

Artificial hydrophillite is probably orthorhombic with a pseudo-tetragonal development, the isotropic material observed by Larsen being a compound of calcium chloride with the index liquids. The birefracting material which later develops along the borders of the isotropic compound probably represents a further reaction with the index liquid.

GREEN SPHALERITE FROM SONORA, MEXICO

R. J. LEONARD, *University of Arizona.*

Sphalerite of an unusually fine green color is prominently displayed in specimens of silver-lead ore recently received by the Department of Geology & Mineralogy, University of Arizona, from the Manzanal mine, near Cananea, Sonora, Mexico.

The sphalerite is massive cleavable, transparent, and varies in color between Ridgway's "Veronese" and "Rivage" greens, XVIII, 31', *d* and *b*, respectively. It occurs with galena in irregular segregations ranging up to one inch in greatest dimension; both are associated with small, prismatic quartz crystals in a gangue composed chiefly of massive quartz and included fragments of wall rock. The ore generally, judging by the specimens at hand, consists essentially of massive galena and tetrahedrite, with some brown sphalerite, in a quartz-barite and older, fragmental quartz-wall-rock gangue.

The period of crystallization of the green sphalerite and associated galena evidently was late in the formation of the deposit. Apparently they occur only in vugs or unfilled portions of a vein, and were deposited after the walls of such openings had been more or less lined with slender prismatic quartz crystals. The galena, partly massive cleavable, partly in distorted octahedral crystals, obviously was deposited first, as it commonly rests on and between the quartz crystals, with green sphalerite in turn on the galena. Occasionally, however, the order may be reversed, or sphalerite may be in contact with the quartz crystals, with little or no galena present. Some of the galena has a notably etched appearance. Sericite is abundant in all specimens and is conspicuously associated with the older gangue, while leverrierite is prominent in some as a heavy white coating on crystals of galena and quartz.

REVIEWS

MIKROSKOPISCHE PHYSIOGRAPHIE DER MINERALIEN UND GESTEINE. H. ROSENBUSCH, Vol. I, Second Half, 5th edition, enlarged and revised by Dr. O. Mügge. Octavo, pp. xvi, 814, with 221 figures, 35 plates and 17 double-page tabular summaries. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, published in three parts in 1925, 1926 and 1927. (For reviews of the First Half, see *Am. Mineral.*, VII, 1922, p. 211; IX, 1924, p. 172; and X, 1925, p. 155).

This well-known work is a very complete account of the microscopic characters of the rock-forming minerals. Mügge has retained the arrangement of the earlier editions so that minerals are described in the order of decreasing symmetry of the crystal systems to which they belong, while the order within each crystal system follows Groth's chemical classification. He has revised the fourth edition very thoroughly and also added greatly to the value of the work by more complete descriptions of the modes of occurrence of minerals and some discussions of their physico-chemical relations. He has also included many minerals not described in

earlier editions, especially those found in the deposits of salt lakes. The extent of the additions is indicated by the fact that the fifth edition is slightly more than twice as large as the fourth edition, and this increase is rather uniformly distributed in all parts of the work.

One of the features of the book is the abundance of references to the literature; these are assembled in lists at the end of each descriptive unit; for example, there is a list of 179 references at the close of the description of the monoclinic amphiboles. The bibliographies are very complete for German literature. The manuscript of the book was completed in the spring of 1924 and publications of later date in general are not mentioned.

Chemical analyses of minerals are given only in special cases, such as the amphiboles, for which formulas are somewhat unsatisfactory. Two of the plates are reproductions of Dr. Mügge's diagrams showing the relations between extinction angles and orientation of the section for tetragonal and hexagonal minerals. The author is to be congratulated upon the completion of a great work of reference.

A. N. WINCHELL

ATLAS DER LETZTEN LINIEN DER WICHTIGSTEN ELEMENTE.

FRITZ LÖWE. Abteilungsvorsteher im Zeiss-Werk. 44 pages and 16 plates of photographs. Verlag von Theodor Steinkopff. Dresden and Leipzig, 1928. Price 12 R.M.

In the booklet the author describes the method of making quantitative analyses for traces of elements by comparing the intensities of the lines in photographs of short-wave, persistent spectrum lines, obtained from the material under examination, with the intensities of the same lines in photographs of the spectra obtained with concentrations of the elements looked for, ranging from 0.001% to 1%. These percentages represent the number of grams of the respective elements in 100 cc. of solution of chloride.

The set up of the apparatus needed to produce the spark, the voltage of the primary alternating current, the capacity of the condenser and the dimensions of the self-inductance coil in the secondary circuit are given, as are also reproductions of 64 photographs of the portions of the spectra (mainly ultraviolet) which contain the lines used. Each photograph has a wave-length scale at the top and then in order, the lines of the dry carbon electrodes (ordinary lighting carbons are used), the lines from 1%, 0.1%, 0.01% and 0.001% solutions, and again those of the dry carbons. This arrangement shows clearly the changing intensities of the persistent lines. The elements covered in these photographs are Ag, Al, As, Au, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Er+Y, Fe, Hg, Ir, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Pd, Pt, Sb, Si, Sn, Sr, Ta, Te, Th, Ti, Tl, V, W, Zn, and Zr.

In addition the book contains an extensive bibliography with discussion of some of the literature on the subject. At the end is a table of persistent lines in the order of increasing wave-lengths, stating for each line the element which gives rise to it, whether obtained by means of arc or spark, their intensities and the wave-length of the next line in the table, of the same element.

The book contains in compact form much that could, without it, be found only by extensive study of the literature on the subject and appears to be well worth a place in every chemist's library, especially of one interested in analytical chemistry.

D. M. LIGHTY

SOIL MINERALOGY—A DISCUSSION OF MINERALOGY IN ITS APPLICATION TO SOIL STUDIES. FREDERICK A. BURT. vii+82 pages, 6 figures and 4 tables. D. Van Nostrand Co., Inc., *New York*, 1927.

In this small book of 82 pages the author, who has had considerable teaching experience in agricultural and engineering colleges, has attempted to fill a need for an elementary text for students of soils.

After introductory chapters dealing with the physical properties of minerals, the elements of soil minerals, and general principles covering the weathering of minerals, the major portion of the text is devoted to a description of 66 minerals which occur in soils. The effects of some of these minerals, harmful or beneficial to plant growth, are also referred to in some instances. Short tables are likewise included to illustrate the relative weathering resistance and volume changes of minerals during alteration, as well as for the determination of minerals.

The book should prove helpful to beginners in a short course on soil mineralogy, although a somewhat more adequate discussion of soils would have extended considerably the usefulness of this text.

W.F.H.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences, January 3, 1929

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the president, Mr. Trudell, in the chair. Forty-five persons, including twenty-six members, were present. The following were proposed by Mr. Cienkowski for junior membership: Messrs. Vincent Kleyla, Herbert Kurtz, William Leavitt, Harry Pollock, Lamar Witmer, Robert Morris and Alexander Flemeý.

A symposium on "*quartz*" constituted the program of the evening, under the direction of Mr. Charles Toothaker. Mr. Toothaker exhibited a fine series of crystals and introduced the subject with remarks on the general properties of the mineral, and its crystal forms. Mr. Boyle exhibited quartz from Hybla, Ontario, showing cracks developed by proximity to radioactive minerals. Mr. Trudell and Mr. Frankenfield exhibited specimens showing inclusions, both of other minerals and of liquids and gases. Messrs. Boyle and Biernbaum contributed remarks on the colors, and their causes, in amethyst and smoky quartz, and other varieties of this mineral. Mr. Gordon spoke on the members of the system SiO_2 ; α quartz, β quartz, α tridymite, β tridymite, α cristobalite, β cristobalite, and glass, and their stability.

The chair appointed judges to examine the exhibits made by the junior mineralogists of specimens gathered during the past year. First, second, and third prizes were awarded to Messrs. Day, Squiers, and Gottshalk, respectively.

SAMUEL G. GORDON, *Secretary*

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, February 7, 1929

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the president, Mr. Trudell, in the chair. Forty-nine persons were present including thirty-three members. Upon favorable recommendation of the council the following were elected junior members: Messrs. Vincent Kleyla, William Leavitt, Harry Pollock, Lamar Witmer, Robert Morris, Alexander Flemey, and Herbert Kurtz. The names of the following were proposed for junior membership: Messrs. Frederick Becker and Rolin Harrold.

Dr. George Rosengarten addressed the Society on "*The Inside of a Crystal*." The general nature of matter and light were discussed briefly, introductory to an exposition of the use of X-rays in the determination of the structure of crystals. Various methods were outlined, and charts and a model of a halite crystal were used to illustrate the lattice structure. A lively discussion of the subject followed.

Mr. Oldach reported on two trips to the recently abandoned French Creek iron mines. Dr. Cajori reported on a trip to Portland, Conn., where specimens of beryl were obtained.

SAMUEL G. GORDON, *Secretary*

THE MINERALOGICAL SOCIETY (ENGLAND)

Mineralogical Society, January 15, 1929. Dr. G. T. Prior, F.R.S., President, in the chair.

Prof. A. HOLMES and Dr. H. F. HARWOOD: *The tholeiite dikes of the north of England.* The suite of tholeiite dikes in the north of England, bounded on the north by the Acklington dike and on the south by the Cleveland dike, form an outlying part of the Mull swarm. To the Salen, Brunton and Talaidh types already recognized in Mull the authors add Cleveland and Acklington types, and anorthite-bearing varieties of each. Chemical and mineral analyses are presented, and from a comparative study of the evidence it is shown that there are many features in the series as a whole which are not in accordance with the theory of crystallization-differentiation.

Mr. A. RUSSELL: *On the occurrence of gold at Hope's Nose, Torquay, Devonshire.* A detailed description is given of a remarkable occurrence of crystallized arborescent gold in calcite, in Middle Devonian limestone at Hope's Nose, where it was discovered by Professor W. T. Gordon in 1922. Specimens many of which are extremely beautiful have since been obtained from five distinct veins. The gold varies in color from a bright rich gold to almost silver-white, and has a silver content of only 1.89 to 8.41 per cent.

Mr. H. E. BUCKLEY: *Crystallography of some organic compounds.* Collected records of goniometric measurements on crystals of various organic compounds.

W. CAMPBELL SMITH, *General Secretary*